of the egg when it contains two astrospheres with the gamete nuclei is of great interest, and this phase of the subject is worthy of extended study. I have seen and figured eggs in Saprolegnia with two coenocentra, each accompanied by a nucleus, when it was evident that the two were sister structures included within the same egg origin.

It is evident that very much more work must be done both in the Saprolegniales and Peronosporales before some of the points suggested by TROW'S paper will be established. An ovcentrum arising from an aster associated with a reduction mitosis is a very different sort of conception from our present idea of the coenocentrum in the Peronosporales. The same sort of structure is also reported to appear suddenly beside the sperm nucleus after its entrance into the oogonium. It seems hardly conceivable that similar structures could behave in such different ways or could hold relationships to the coenocentra of the Peronosporales. Of course my own view of the essential agreement of the Saprolegniales and Peronosporales in processes of oogenesis around coenocentra must await the results of future investigations.—B. M. DAVIS, *The University of Chicago.*

THE SEXUAL ORGANS AND SPOROPHYTE GENERATION OF THE RHODOPHYCEAE.

OLTMANNS'S theory that the structure developed from the fertilized carpogonium in the Rhodophyceae represents a sporophyte generation has received substantial confirmation in recent cell studies of WOLFE[1] on Nemalion. This investigation also makes an important contribution to our knowledge of the sexual organs of the red algae, establishing some complications of structure that are likely to prove very general in the group, and quite changes our conception of their morphology. Their possible relations to the sexual organs of the lichens, Laboulbeniaceae, and even to the Uredineae is full of interest.

The trichogyne of Nemalion contains a well defined nucleus which appears shortly after this structure begins to push upward from the carpogonium, but is only found in a fragmented condition in the mature trichogyne. The egg nucleus, which lies above the chromatophore in the carpogonium during the early development of the trichogyne, passes later to the bottom of the carpogonium. Although no mitotic figure was observed it seems clear that the nuclei of the trichogyne and egg are sisters, following a division in the terminal cell of the procarp.

These observations on Nemalion confirm my account of the trichogyne

[1] WOLFE, J. J., Cytological studies on Nemalion. Ann. Botany **18**:607–630. *pls. 40–41.* 1904.

of Batrachospermum,[2] which I described as a nucleated cell with a chromatophore, and whose long life was accounted for by these complexities of structure. Later investigators, SCHMIDLE[3] and OSTERHOUT,[4] failed to find the trichogyne nucleus, but I am confident that my account of this structure is substantially correct. It is probable that nucleated trichogynes will be discovered in other red algae, and indeed they are likely to be quite general in the group, for the great length of these structures is much more readily understood as nucleated appendages than as cytoplasmic extensions from the small carpogonia. We shall have to recast our conception of the female sexual organ of the red algae. Instead of being a uninucleate cell (oocyst) with a filamentous cytoplasmic receptive outgrowth, we shall probably have at least a two-nucleate structure with the trichogyne obviously very much like a second cell in the organ.

These complications, puzzling at first thought, may clear up some very difficult problems of morphology. I refer to the multicellular trichogynes of the lichens and Laboulbeniaceae. They will not seem to be so far removed from the female organs of the red algae if trichogyne nuclei prove to be general, and we may come to regard them as the highest expressions of this growth tendency on the part of a primitive type of unicellular organ. BLACKMAN'S[5] recent investigations in the Uredinales indicate that female sexual organs are present in some forms (e. g., Phragmidium), and the presence of a sterile cell above the fertile is wonderfully suggestive of a trichogyne. All the female organs with multicellular trichogynes form a group quite by themselves, and apparently without relation to other multicellular sexual organs (gametangia). Since the cells are probably connected with one another by broad strands of cytoplasm, the physiological conditions may be very close to those of multinucleate sexual organs (coenogametes).

The sperm (spermatium) of Nemalion is formed singly in the spermatocyst and leaves this structure as a uninucleate naked or thin-walled mass of protoplasm. But before fertilization the original nucleus of the sperm divides with a mitotic figure, so that two male nuclei are formed and both enter the trichogyne. SCHMIDLE reported binucleate sperms in Batrachospermum, and some of my own figures show the same conditions, which, however, I explained as phenomena of fragmentation. It is evident that the sperm discharged from the spermatocyst (antheridium)

2 DAVIS, B. M., Ann. Botany **10**:49. 1896.

3 SCHMIDLE, Bot. Zeit. **57**:125. 1899.

4 OSTERHOUT, Flora **87**:109. 1900.

5 BLACKMAN, Ann. Botany **18**:323. 1904.

involves all of the protoplasm of this mother-cell, and the mitosis is a relic of times when more than one sperm was formed. The present binucleate sperm is a simple type of multinucleate gamete (coenogamete).

Both male nuclei are discharged into the trichogyne of Nemalion, which at the time of fertilization contains no organized nucleus. One male nucleus passes into the carpogonium, in the upper portion of which it meets the female nucleus and here fusion takes place. Several sperms may unite with and discharge their contents into the trichogyne, but supernumerary male nuclei soon break down. The fertilization of Batrachospermum undoubtedly takes place in essentially the same manner as described by SCHMIDLE and OSTERHOUT, but both of these observers failed to understand the complications of the trichogyne. On the other hand, I was misled by these complications and failed to discover the essential act of fertilization as a nuclear fusion in the carpogonium.

The development of the cluster of fertile filaments (gonimoblasts) follows the older accounts, but WOLFE contributes a new point of importance in showing that the carpospores are developed successively at the ends of the filaments. When one spore has been discharged the cell behind grows into the old cavity and develops there a new carpospore. This method of spore formation by successive proliferations is well known in certain groups of fungi, but among the algae has so far only been described for the Rhodophyceae.

The cytological evidence that the cystocarp is a sporophyte generation rests with a count of the chromosomes in mitotic figures at different periods of the life history. The number is about eight for the gametophyte, as shown in vegetative mitoses and during spermatogenesis. Mitotic figures were easily found at certain stages in the development of the fertile filaments (sporophytic), and these always presented an approximate double number of chromosomes, about sixteen. The numerical reduction of the chromosomes seems to take place just previous to spore-formation, for nuclear figures in the terminal cell of the older fertile filaments had quite the same appearance as those of the gametophyte and showed eight chromosomes. The manner of the reduction was not determined.

WOLFE gives some interesting details of cell and nuclear structure. The chromatophore of Nemalion has the form of a hollow ellipsoid, the center being a vacuole and not a pyrenoid. The chromatin of the resting nucleus is present in the form of a globular body (nucleolus). During prophase the chromatin passes along fibrillae to the nuclear wall. The spindle is intranuclear and centrosomes are present at its poles during metaphase.—B. M. DAVIS, *The University of Chicago.*